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THE DISTRIBUTION, ABUNDANCE AND HABITAT PREFERENCES OF AMPHIBIANS AND REPTILES IN SOUTHWESTERN IMPERIAL COUNTY

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(THE DISTRIBUTION, ABUNDANCE AND HABITAT PREFERENCES OF AMPHIBIANS AND REPTILES IN SOUTHWESTERN IMPERIAL COUNTY)

STATUS OF TUBERCULATE GECKOS IN SOUTHERN CALIFORNIA

A Report Prepared For

Bureau of Land Management
Desert Plan Staff
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TABLE OF CONTENTS

Introduction 1

Materials and Methods. 2

Results. 3

Identity and Taxonomic Status 3

Description of Specimens from Southern California 4

Coloration in Life. 6

Baja California Sur 8

Baja California Norte 8

Identification. 9

Distribution. 9

Comparisons with Coleonyx reticulatus and Other Species of Coleonyx 10

Ecology and Habits. 15

Faunal Associations 17

Behavioral Observations in Captivity. 18

Abundance, Activity Patterns and Ecological Status. 19

Acknowledgements 26

Literature Cited 27

List of Figures 28

Figures 1-10

Tables 1-2

Appendix I

Appendix II

INTRODUCTION

The reptiles and amphibians of western Imperial County and adjacent eastern San Diego County have been studied by the author over a period of four years. However as a direct result of the discovery of a previously unknown gecko of undetermined status in desert regions of southern California, fieldwork was expanded in intensity and focused on appropriate habitats for maximal informational yield. The provision of contract CA-960-4350-5573-DE00 by the Bureau of Land Management facilitated field studies in the Jacumba, Coyote and Fish Creek Mountains in 1976 and resulted in the expansion of existing knowledge of the enigmatic gecko and the complex reptilian fauna with which it is associated. Southern California has been the object of exhaustive herpetological studies since the 1920's when Lawrence Klauber began his zoological career which served as a basis for a vast array of subsequent investigators. The fact that the enigmatic tuberculate gecko eluded detection and study until the present decade relates to the difficulty with which the rock habitats which it inhabits are entered and studied. The gecko which is herein considered as Anarbylus switaki Murphy is apparently restricted to extremely rocky habitats where it passes most of its life in crevices and subterranean chambers. In showing relationships with more primitive geckos from humid areas of tropical Mexico and Central America, its presence in southern California must be viewed as relictual with rock habitats tempering the otherwise excessive temperatures and aridity characteristic of the western Colorado Desert.

As a result of the above considerations, primary emphasis has been placed on studying specific habitats in each of the three mountain ranges

where the new gecko was known or expected on the basis of other biotic and physical factors. Previous reports (Fritts 1977; 1978) to the Bureau of Land Management California Desert Plan Staff have detailed information on the reptilian and amphibian fauna of southwestern Imperial County and this information is not repeated in the present report.

MATERIALS AND METHODS

Following the initial discovery of the tuberculate gecko in 1976, a search was made in southern California for additional information and other individuals. Since the lizard was collected in an area of extensive exposures of granodiorite and other intrusive igneous rocks on the eastern slopes of the southern coastal range, initial fieldwork was concentrated in similar habitats in western Imperial and eastern San Diego Counties. Although much of this habitat occurs within Anza-Borrego Desert State Park and Park authorities were cooperative in authorizing fieldwork for research activities, the major emphasis was placed on an area outside of Park boundaries. A study area in the Jacumba Mountains bounded approximately by Jacumba, California on the west, Interstate Highway 8 on the north, Ocotillo, California on the east and the border of the United States and Mexico on the south has been studied most intensively over a three-year period. Other study sites were also established in the Coyote and Fish Creek Mountains.

The areas were searched on foot at irregular intervals concentrating on looking under rocks, plant litter and other objects on the substrate. Cavities under exfoliating flakes of rock and other crevices were examined closely whenever possible. In order to minimize habitat disturbance, other collecting methods were also employed. A total of 100 pitfall traps in linear

series of ten traps each were monitored from April-June, 1978, in the three study areas.

The locations of these pitfalls and habitats sampled are listed in Appendix 1. All pitfalls consisted of a five gallon metal can buried with the opening flush with the substrate. Each was equipped with a top suspended 3-7 cm above the substrate and sufficient soil in the bottom to buffer temperature extremes. Although two sets of 10 pitfall series were deliberately placed in open valley floors and bajada habitats, the remainder were located as closely as possible to rock exposures. This often entailed using a pick to excavate decomposed rock or compacted gravels contiguous with adjacent rock exposures. Pitfalls were usually monitored at 7-10 day intervals and were employed from March through June, 1978.

Nocturnal searches on foot with battery-powered head lamps were made in the Jacumba Mountains and nocturnal road driving was employed in the few areas where surfaced roads transected appropriate rock habitats.

Descriptions of color patterns and other noteworthy features were made and color photographs were taken of all tuberculate geckos encountered. Morphological comparisons with other geckos were made utilizing specimens loaned by the California Academy of Sciences, Texas A & M University and San Diego State University.

RESULTS

Identity and Taxonomic Status.--To date seven tuberculate geckos from southern California have been studied. Three of these specimens were collected during 1978 from an equal number of localities. During the same period, material from Baja California was made available to me for study. Most

critical to the determination of the identity of the tuberculate geckos from southern California is a single specimen collected near Bahia Los Angeles, Baja California Norte, Mexico. This specimen is from an intermediate locality between the known range of Anarbylus switaki in southern Baja California, Mexico, and the tuberculate geckos from California which resemble the southern taxon except in coloration and minor scutellational features. Table 1 summarizes morphological comparisons of all samples available.

The specimens from southern California differ significantly in color pattern, coloration and body proportions from the type and other specimens of Anarbylus switaki. The single specimen from Baja California Norte is intermediate in color pattern to geographically extreme samples and provides evidence that all tuberculate geckos at hand are conspecific with Anarbylus switaki (Fig. 1-3).

Description of Specimens from Southern California.--Moderately large eublepharine geckos (snout-vent 53-84 mm; N=7). Head moderately broad, distinctly wider than neck in adults; head and snout uniformly covered with granular scales, those of snout and canthal region slightly larger than other head scales; rostral large, slightly wider than high, with convex but not sharply pointed posterior margin. Large prenasal separating nasal from rostril on each side of head; prenasals separated by a single granular scale medially. Large nearly circular supranasals separated from each other by 3-4 scales. Postnasal border variable, consisting of 1-2 scales, when two postnasals, ventral scale is large, the dorsal postnasal is granular and occasionally incompletely divided. Eyelids covered with granular scales except for superciliaries which are strongly tuberculate producing an orbital fringe. Scales bounding superciliaries on interior surface of eyelids platelike and rectangular. Mental scale rounded posteriorly and bounded by granular scales

between infralabial rows. First and second infralabials bounded ventrally by larger scales than those on remainder of chin and gular region. Supralabials decreasing in size posteriorly, 9-11 in number counting from scale contacting rostral to most posterior scale on supralabial row that is 2X size of adjacent granular scales and contacting a fold of skin originating in the suborbital area and extending postero-ventrally across angle of jaw. Infralabials 11-12 counting from scale contacting mental to most posterior infralabial contacting last supralabial when mouth is closed. Auricular opening eliptical, higher than wide, with fold of skin on dorsal and anterodorsal borders; tympanum visibly recessed.

Scales of neck and dorsal body predominantly granular. Few enlarged tubercular scales among smaller granules on neck immediately anterior to pectoral region. Entire dorsal and lateral body and dorsal base of tail anterior to caudal constriction with enlarged tubercles approximately 3X the size of the granular scales between tubercles. Tubercles conical, elevated above skin surface, separated from each other by 2-4 granules. Tubercles on lateral body reduced in size and number whereas granular scales increase in size ventrolaterally and grade into large imbricate scales of venter. Umbilical scar demarcated by a paired series of scales separated by a medial furrow. Scales of venter near pelvic region larger than adjacent ventrals, with inconspicuous precloacal pores in males; pores absent or indistinct in females and juvenile.

Scales of dorsal tail slightly larger than dorsal body scales, more rectangular, arranged in transverse rows which vary in size producing discernable whorls or caudal rings which possibly represent autonomic segments of caudal appendage. Whorls include 5-7 transverse rows of caudal scales. Whorls coinciding with banding of tail with black bands spanning

1 whorl of 7 scales whereas white bands tend to encompass two such whorls or 14 transverse rows.

Cloacal spurs variable in size depending on sex; external cloacal tubercles of male longer, more pointed and recurved than the cloacal tubercles of females which are triangular with the base slightly wider than the height with a slight groove on dorsal surface. Cloacal tubercles originating slightly ventral to the dorsal edge of the hind limb insertion at the level of the cloaca, and projecting dorsally.

Limbs covered with granular scales and lacking enlarged tubercles. Digits of limbs moderate in length; second, third and fourth fingers subequal in length; toes increasing in length from first to fifth. Bases of claws on toes enclosed by a sheath of four scales. Sheath composed of a narrow dorsal scale, a pair of lateral scales and a ventral scale which forms the terminal scale of the series of subdigital lamellae. Claw moderately exposed from sheath with dorsal sheath scale not extending as far distally on the claw as the ventral and lateral sheath scales. Distal subdigital lamellae are larger than adjacent scales on lateral edge of the toes, wider than long and moderately imbricate. Lamellae of ventral toe surface proximal to most distal 4 scales reduced in size, grading into narrower and more tuberculate scales proximally; basally they resemble the granular tuberculate scales of adjacent rows and project from the skin surface rather than overlapping. Ventral surface of toe with five rows of scales visible near base; 17-18 scales along central row of lamellae from base of fourth toe to ventral claw sheath scale. Ventral surface of toe denticulate when viewed laterally; subdigital lamellae of manus similar to those of pes; 14-15 subdigital lamellae from base of fourth finger to ventral claw sheath scale.

Coloration in life.--Dorsal head and body light greybrown with indistinct

medium brown spots; head with scattered distinctly defined white spots. Labials dull white with slight mottling of medium brown; superciliaries white except on distal tips of eye fringe and on interior surface of eye which is dull black. Medium brown stripe bounded by indistinct white stripes from nostril to anterior margin of eye. White spots immediately posterior to occiput arranged in irregular transverse rows; another transverse row of yellowish white to white spots which are incompletely fused forming a light transverse band across lateral and dorsal neck anterior to the insertion of forelimbs. Five to seven complete transverse bands of off-white color on body between pectoral and pelvic girdles. Two yellow-white bands between anterior margin of hind limb insertion and caudal constriction which is a wider band varying in color from dull white to bright yellow. Vertebral line beige, indistinctly defined and devoid of large tubercular scales. Numerous black spots corresponding to pigmented, enlarged tubercles, remainder of tubercles pigmented with dorsal ground color or that of light bands depending on location. Juvenile lacking black pigments on dorsal body and adults with varying quantities of dark spots on body.

Tail posterior to caudal constriction with alternating transverse bands of black and white. Basally white bands approximately twice as large as black segments. Dark band immediately posterior to caudal constriction charcoal grey with lighter area near middle of band; distal black bands intensifying slightly; eight black bands from caudal constriction to tip of tail and 8 white ones. Limbs light beige with indistinct small clusters of medium brown pigment. Venter pinkish white.

Of the seven specimens and photograph of an additional specimen available to me, only one shows a tendency to have transverse rows of white spots instead of continuous white bands on the body. The exceptional specimen (TCWC 0000)

from Montezuma Grade, San Diego County, California) has transverse rows of white spots which are sufficiently closely spaced to form nearly continuous bands with scalloped margins suggesting fused spots rather than a solid band. This specimen has six complete transverse rows and two half rows (one per side). It also is significant that no ontogenetic change in banding pattern is apparent in the specimens in hand. The single juvenile has white unbroken transverse body bands resembling adults of A. switaki and differs conspicuously only in lacking mottling of dark pigment on the body.

Baja California Sur.--These specimens differ from the above specimens in having rows of white spots (yellow in life) extending onto the body and base of the tail to the caudal constriction. The number of rows between limbs and from forelimbs to the caudal constriction is higher than that of northern populations. Individuals with significant portions of the original tail have black bands with light charcoal grey centers on the proximal half of the tail and bands more uniformly pigmented on the distal tail. The dark spots and blotches on the head, neck and body are conspicuous with well-defined borders and therefore tend to obscure the presence of light spots in preserved specimens. Snout-vent lengths in three specimens are 73, 83 and 85 mm.

Baja California Norte.--The single specimen at hand is similar to Californian specimens except in having more light bands or rows of spots and in having transverse rows of spots extending onto anterior body from the head and neck region (Table 1). There are two rows of white spots posterior to the forelimbs, followed by two transverse white bands which break into rows of spots near the vertebral area and on the right side of the body. The fifth and sixth bands are continuous across the body except at the vertebral line, and are followed by two irregular transverse bands which are broken into segments of 2-3 incompletely fused spots. Posterior to the hindlimb

insertion is a transverse band followed by a wider white band at the caudal constriction. The 4 black bands visible on the incomplete tail are densely pigmented on their anterior and posterior margins but consist of lighter charcoal grey pigmentation in the centers. The snout-vent of the adult male is 69mm.

Identification.--Anarbylus switaki can be distinguished from all other eublepharine geckos in North America by the presence of subdigital lamellae which are small and similar to adjacent scales on the toes, and by the distinct black and white bands on the tail.

It is also distinguished from Coleonyx variegatus, with which it is sympatric, by the presence of enlarged tubercles on the dorsal body. A key to North American eublepharines is included as Appendix 2.

Distribution.--Anarbylus switaki Murphy (1974) was named on the basis of a single specimen collected near San Ignacio, Baja California Sur, Mexico, and this specimen is the only one reported to date in scientific literature. Additional specimens from Baja California Sur collected by Robert Murphy and John Ottley in 1978 extend the range of Anarbylus to the south from San Ignacio to the vicinity of Santa Rosalia. In addition a specimen of Anarbylus from the vicinity of Bahia Los Angeles, Baja California Norte, Mexico, was obtained by Murphy and Ottley (Robert Murphy, pers. com.) and has been made available for comparison with specimens from Baja California. Thus Anarbylus switaki is known over a 700km range in a north-south line between northern San Diego County and Santa Rosalia, Baja California Sur.

Within southern California, Anarbylus switaki is known from seven specimens from five distinct areas (Fig. 4).

1. An adult female collected by Randy Lindburg Martin. California: Imperial County: vicinity of North Fork of Pinto Canyon, ≈500m, 6 January 1976. T17S;R9E;Sec26;NW¼.

2. A juvenile collected by T. H. Fritts and H. L. Snell. California: Imperial County: 1 km NW of junction of Pinto Canyon and Davies Valley near U.S./Mexican boundary (12.5 km S Ocotillo, California), 370 m, 2 October 1976. T17S;R9E;Sec1;NW¼.

3. An adult female collected by P. R. Fritts. California: Imperial County: Davies Valley, 10 km S Ocotillo, California, 425 m, 9 October 1976. T17S;R9E;Sec25;SE¼.

4. An adult male collected by L. Grismer. California: Imperial County: 2 km E Culp Valley Primitive Camp on California State Road S22, 12 June 1978. T11S;R5E;Sec15;SE¼.

5. An adult male collected by P. R. Fritts and M. Stinson. California: Imperial County: Painted Gorge, 9 km N Ocotillo, 200 m, 20 May 1978. T16S;R9E;Sec2;NW¼.

6. An adult female collected by B. Barr. California: Imperial County: 3 km E Mountain Springs on Old Highway U.S. 80, 586 m, 31 May 1978. T16½S;R9E;Sec21,NW¼.

7. An adult female collected by C. Joynter. California: Imperial County: 2 km S Yaqui Pass on Yaqui Pass Road, ≈ 480 m, 21 June 1977. T12S;R6E;Sec9;SW¼.

Specimens collected by Martin and Joynter are in the possession of Randy Lindburg Martin; all other specimens are in the author's possession and will be deposited in the California Academy of Sciences, National Museum of Natural History and the Texas Cooperative Wildlife Collections at Texas A & M University.

Comparisons with Coleonyx reticulatus and Other Species of Coleonyx.--In 1956 Davis and Dixon (1958) discovered the first specimen of Coleonyx reticulatus in an area of Texas previously considered to be well known

herpetologically. Despite collecting efforts by a variety of herpetologists, additional specimens were not collected until 1971 (Siefert and Murphy, 1972) and only in recent years have the systematic relationships (Kluge, 1975), ecology (Dial, 1978a; 1978b) and general distribution of the species been clarified.

A closely parallel situation apparently exists in southern California and Baja California with the recent discovery of Anarbylus switaki (Murphy, 1974; Fritts, 1977).

Because of several conspicuous similarities, it is informative to compare Anarbylus switaki as presently understood with species of the genus Coleonyx. Coleonyx reticulatus resembles Anarbylus in being a tuberculate gecko with a predominately northern distribution. In having large tuberculate scales on the dorsal body, both A. switaki and C. reticulatus resemble more primitive Coleonyx species in tropical areas of southern Mexico and Central America and differ markedly from the other northern species C. brevis and C. variegatus. C. reticulatus occurs in sympatry with C. brevis whereas Anarbylus switaki occurs in sympatry with C. variegatus. As presently understood C. reticulatus is restricted to rock habitats and so too are all populations of Anarbylus. Both species are relatively recently discovered (1958 and 1974, respectively) even though they occur in extensively studied areas. Both are relatively rare and spend most of their lives deep within crevices and subterranean chambers of rock formations. C. reticulatus has been shown to prefer cooler and moister environmental conditions than the widespread species (i.e., C. brevis) that occurs in sympatry with it (Dial, 1978a; 1978b). Preliminary studies on preferred ambient temperatures of Anarbylus switaki and C. variegatus suggest that the former selects cooler temperatures than the latter.

Both on the basis of morphological similarity and ecological tolerances, C. reticulatus can be viewed as more closely related to the more primitive tropical species than to northern more arid adapted taxa. C. reticulatus may be a relictual species from more mesic and tropical climates which became restricted to rock dwelling habits as the variable temperatures and arid conditions of North American deserts developed during the Pleistocene (Kluge, 1975).

The two tuberculate geckos occupying northern distributions have apparently undergone selective pressures for increased area of subdigital lamellae in the rock habitats inhabited. However, C. reticulatus has responded to such pressures by increasing the number of subdigital lamellae in the central row whereas A. switaki has narrowed the central row allowing adjacent tubercular scales to invade the ventral digital surface. These differences suggest that two evolutionary lines have diverged from ancestral terrestrial Coleonyx to invade rock habitats. These two lines are also distinguished by the position of the cloacal tubercle on the base of the tail. The cloacal tubercle of switaki originates from the dorsolateral margin of the tail whereas that of reticulatus originates in the ventrolateral quarter of the tail. C. brevis and variegatus exhibit the former character state whereas C. elegans and mitratus exhibit the latter.

Except for those of C. reticulatus, the number of subdigital lamellae along the length of the digit is relatively constant within the genus Coleonyx and Anarbylus. However a survey of the morphology of subdigital scutellation indicates that significant variation exists. The subdigital lamellae of C. elegans and C. mitratus are relatively wide, flat scales which occupy most of the ventral surface of the digit and are progressively wider proximally. When viewed ventrally only the central row of subdigital lamellae

and a row of smaller imbricate scales on each side of this row are visible. The scales bounding the subdigital lamellar row are approximately 25-30% of the size of the lamellae along most of the length of the digit.

In contrast to the three to four rows of scales visible on the ventral digits of C. elegans and C. nitratus, five rows are visible on those of C. variegatus, C. brevis, and C. reticulatus. The central row of subdigital lamellae of C. reticulatus are relatively large like those of C. elegans and C. nitratus but are bounded by smaller scales which are more tuberculate than imbricate. The central row of C. reticulatus is widest near the middle of the digit and slightly narrower near its proximal and distal extremes. The subdigital lamellae of C. variegatus and C. brevis are less conspicuously enlarged in relation to adjacent scales. The granular scales adjacent to the central row of lamellae are approximately 50% of the size of the individual lamellae. The scales of the central row decrease in size proximally whereas adjacent scales increase in size proximally. As a result the scales of the central subdigital row are subequal in size to adjacent scales near the base of each digit and some lamellae are only slightly wider than long.

The subdigital lamellae in the central row of A. switaki are smaller than those of other species but are only slightly reduced in relation to C. variegatus and C. brevis. The most distal 3-5 scales of the central subdigital row of A. switaki are wider than long and indistinguishable from corresponding scales of C. variegatus and C. brevis. All other scales proximal to these scales are small and triangular which together with adjacent scales produce a denticulate central surface. Five to seven scale rows are visible on the ventral digits of A. switaki. The scales bounding the central lamellae are slightly smaller but are similar in being triangular denticulate scales which do not overlap. The central row is morphologically distinct from

adjacent rows distally but grades to small scales proximally which visually blend with adjacent scales. Functionally the difference between switaki and brevis/variegatus is one of decreased size of the central row of subdigital lamellae allowing the invasion of adjacent scale rows from ventrolateral to ventral surfaces of the digit, thereby increasing the number of individual scales contacting a flat substrate and increasing the denticulation of the digital surface. In relation to terrestrial Coleonyx, C. reticulatus also has more scales contacting the substrate but this difference results from increasing the length of the digit instead of adjusting the transverse proportions of existing scutellation.

Subjectively the transition from the large flat subdigital lamellae of elegans and mitratus to the reduced tuberculate lamellae of switaki can be viewed as a gradual trend with variegatus and brevis occupying an intermediate position between the two extremes.

Since similarities exist between Anarbylus switaki, Coleonyx reticulatus, C. brevis and C. variegatus, it is potentially informative to view Anarbylus switaki in the existing evolutionary hypothesis to attempt to determine relationships and evaluate generic status. Using the hypothesis which Kluge (1975) developed on the basis of osteological characteristics for the five species of Coleonyx studied by him, it is possible to superimpose other characteristics which appear to be concordant (i.e., involving no reversals or parallelisms) with Kluge's scheme. Subsequently the evaluation of A. switaki for the same characteristics provides a tentative positioning of the taxon (Fig. 5). Although the use of Kluge's hypothesis based on an independant set of data forces some constraints on the interpretation, the existance of a large number of external morphological characteristics which complement the trends suggested by the osteological evidence, allows maximal predictive value in a preliminary estimate of the relationships of Anarbylus.

In Fig. 5 it is apparent that both C. reticulatus and Anarbylus are more advanced than C. mitratus and C. elegans but evolved prior to C. variegatus and C. brevis. However they are separated by significant differences in the position of the cloacal tubercle, the structure and number of subdigital lamellae and the karyotype. The similarity of the cloacal tubercles of A. switaki, C. brevis and C. variegatus form the basis of the suggestion that A. switaki originated after the line giving rise to C. reticulatus had diverged.

If such an evolutionary relationship is supported by additional evidence such as osteological or electrophoretic analyses of biochemical phenotypes, the desirability of recognizing the genus Anarbylus as distinct from Coleonyx is doubtful.

Ecology and Habits.--The seven individuals of Anarbylus known to date represent seven localities although three were found within close proximity in the Jacumba Mountains. Fig. 4 shows the location of each of the localities where Anarbylus is known and the approximate limits of a habitat association termed the desert foothills by Klauber (1931). This zone includes the transition between Upper Sonoran and Lower Sonoran Life Zones. The area is predominately covered with igneous rock formations which make up the eastern escarpment and slopes of the southernmost extension of the coastal range in the United States. The vast majority of the desert foothill association consists of intrusive igneous rocks of granitic form. These formations are probably Cretaceous in age and have subsequently been exposed by erosion and uplifting accompanying the faulting of the coastal range. In the deeply cut canyons such as Pinto Canyon near the Mexican border, a variety of metamorphic strata are exposed but granodiorite and other intrusive igneous rocks and derivative gravels cover the vast majority of the area.(Fig. 6).

Along the eastern edge and at lower elevations, these slopes are broken by valleys which often lack rock exposures due to thick alluvial deposits. Also on the eastern edges of the desert foothills, extrusive igneous formations in the form of outpockets or isolated ridges are more common. The eastern wall of Davies Valley, the Coyote Mountains and areas of the Fish Creek Mountains have few granitic exposures and consist of basalt and brecca of volcanic origin as well as a complexity of sedimentary formations with relatively thin soils. While rock habitats exist in both intrusive and extrusive formations, the finer, more compact and sparser soils along the eastern extrusive areas probably support a lower diversity and density of plant and animal life. Such a conclusion is supported by the sparsity of vegetation, animal burrows and commonest lizard species in these areas. It is likely that these biological differences are also related to the higher temperatures and reduced rainfall of the lower slopes in relation to areas at higher elevations and more contiguous with the main body of the coastal range.

Vegetative density and composition also varies with altitudinal features. At higher elevations of 800-1000m, a mixture of chaparral and more xeric desert species is evident. Near the top of In-Ko-Pah Gorge at 958m, jojoba (Simmondsia), manzanita (Arctostaphylos) and scrub oak (Quercus) are common with scattered clumps of Nolina, Agave, and Yucca whipplei. Sparse stands of pinyon (Pinus monophylla) and juniper (Juniperus) are present on some ridges and other localized areas. Trunks of much larger individuals of pinyon which exist near In-Ko-Pah County Park and large dead trunks of juniper found near Mountain Sprtings are noteworthy and potentially document recent climatic changes in the area and retraction of these species to higher elevations in the recent past. To date Anarbylus is not known to occur at elevations above 600m but its absence from higher elevations remains to be conclusively documented.

At elevations of 300-800m, vegetation is predominately made up of desert species with Agave, Yucca, Opuntia bigleovi, Encelia and Fouquieria forming dense stands between rockpiles and on steep rock slopes. In contrast the periphery of the desert foothills with volcanic and sedimentary exposures are more barren with principal shrub species of Encelia, Ambrosia and Fouquieria in sparse stands.

Anarbylus switaki is known from both diverse and barren areas and apparently depends more on the presence of rock formations than on other ecological factors. Specimens found near Mountain Springs, Davies Valley, Pinto Canyon and Culp Valley were all in close association with granitic exposures at elevations of 300-600m. The specimen from Painted Gorge was taken on a slope with abundant rock rubble derived from igneous, metamorphic and sedimentary deposits at 366m. The single individual from Yaqui Pass was crossing a road adjacent to a ridge densely covered with basaltic blocks. Because of the diversity of situations from which Anarbylus switaki is known, it is possible that it occurs at least in isolated pockets throughout the desert foothills of San Diego and Imperial Counties and adjacent Baja California. From a geological point of view it is possible that Anarbylus switaki extends into Riverside County as far as the pass between San Gorgonio and San Jacinto.

It is apparent that any future work on Anarbylus should be concentrated within the desert foothill association delimited in Fig. 9. Although the taxon is not known from the western margin of this zone except in northern San Diego County, habitat similarities near the southern boundary suggest its possible occurrence over a wider area than presently known.

Faunal Associations.--Consideration of the other reptiles with which Anarbylus has been observed potentially offers insight into its ecology and probable distribution. Klauber (1931) recognized that the desert foothill

area often marked the distributional limits of snake taxa but found no snake to be limited to the desert foothills. In contrast, both Anarbylus switaki and Phyllodactylus xanti are primarily confined to desert foothill situations. Although Urosaurus microscutatus, Sceloporus orcutti, Xantusia henshawi and Petrosaurus mearnsi are known to range further west into chaparral areas, their eastern distributional limits closely coincide with the distribution of Anarbylus in California. All of these lizards have significant distributions in the Baja California Peninsula and appear to reach maximal abundances in desert foothill situations in comparison with coastal or mountainous areas (sensu Klauber, 1931). Urosaurus microscutatus, Xantusia henshawi and Sceloporus orcutti are confined to slightly higher elevations in southern California (i.e., approximately 900m, 800m and 500m, respectively) than Petrosaurus mearnsi, Phyllodactylus xanti and Anarbylus switaki which reach 200m.

Even though Anarbylus switaki is known from a small area of California, it has been recorded in sympatry with an unusually diverse lizard fauna consisting of 20 species (Table 2). This diversity is partially explained by the presence of several taxa previously mentioned with principal distributions in Baja California but which occupy the desert foothills of southern California as well. The presence of such species points out the importance of this area and the need for conservation and management plans considering these species.

Behavioral Observations in Captivity.--Most of the behavioral traits of two Anarbylus maintained in captivity are ones shared with Coleonyx variegatus and other geckos. Both individuals showed a tendancy to drink water droplets from the substrate or the tip of a finger by licking movements of the tongue. The tongue was also used in investigating the heads and vents of other lizards,

both Coleonyx and other Anarbylus, when first placed in the cage. The male showed considerable interest in a female when the latter was introduced into the cage. The male approached the female from the side, appeared to touch the side of her head, neck and vent with his tongue and rapidly vibrated the tail in lateral movement. The female often stood still in a fully extended stance or walked away. The male often followed and occasionally walked over the female from behind and attempted to maintain his cloaca next to that of the female. To my knowledge no copulation occurred. Both individuals tended to hide under a broken clay pot even though another container designed as a hide box was available. Both were capable of being active at all hours of the day or night and were often observed on top of their hide box or walking about the cage. Both were seen to eat mealworms (Tenebrio larvae), isopods and moths. A moth placed in the cage with the two lizards was nearly always perceived and followed visually during flight. The male investigated any Coleonyx variegatus introduced into the cage but showed less pursuit or subsequent attention to these than to the female Anarbylus.

The tail of the male Anarbylus was carried horizontally and usually moved in a lateral undulating pattern when the animal was walking. It rarely lifted the tail vertically as does Coleonyx variegatus.

Both Anarbylus chose cooler temperatures in a temperature gradient than individuals of Coleonyx variegatus tested under identical conditions.

Abundance, Activity Patterns and Ecological Status.--The recent discovery of Anarbylus in a relatively well-known area and the difficulty with which additional specimens were subsequently located is perplexing. The restriction of Anarbylus to rock habitats, its nocturnal habits and the possibility of confusion with Coleonyx variegatus do not satisfactorily account for the rarity of these lizards. Even after the first specimen was discovered, much

field effort and hundreds of pitfall days were spent before additional specimens were encountered.

The situation differs from that of other recently discovered vertebrates with limited distributions. For example Batrachoseps aridus and B. stebbinsi are also limited in distribution but within their specific habitats are easier to find than Anarbylus switaki. Clearly, much remains to be learned about the specific ecology and activity patterns of Anarbylus which remains known from only a few individuals and from nearly as many localities as there are specimens. On the basis of present knowledge, Anarbylus appears to be a relict of more mesic climates and quite distinct from other eublepharine geckos occupying North American deserts. By being restricted to habitats of extreme structural diversity (i.e., rocky areas) and quite sporadic in its activity patterns above ground, it can be hypothesized to be sensitive to the extreme aridity and temperatures characteristic of the area in which it occurs. Like other animals in deserts, Anarbylus probably survives by avoiding desert conditions rather than by tolerating them.

Three specimens were hand collected during daylight hours on the ground under large rocks on 6 January 1976, 2 October 1976 and 9 October 1976. Two other specimens were collected from pitfall traps on rocky slopes on 20 and 31 May 1978, whereas two others were found while crossing asphalt roads at night on 21 June 1977 and 12 June 1978. Although searches for Anarbylus have been conducted during all seasons of the year over a three-year period, no additional specimens were encountered. The fact that two specimens each were independently collected in October, May and June and that a single specimen was collected in January, suggests that Anarbylus probably is most active in spring and early summer just as most other reptiles are. It also suggests that Anarbylus is extremely secretive and probably is usually active beneath the substrate or

within rockpiles and only surfaces during special conditions or during mating or dispersal phases of its life cycle. The environmental cues which might prompt above ground activity and explain such clumped discovery of these lizards are unknown. Specimens collected during daylight periods were found on moderately cool days with high temperatures around 20°C; one specimen was found on a road at 11:00PM when the air temperature was 28°C, and the substrate temperature was 22°C. The latter specimen was found during the first quarter moon and was active in a strong wind.

On the basis of existing knowledge, the following can be concluded.

1. Anarbylus in the United States is restricted to specific rock habitats in a narrow zone of desert foothills.

2. It is either extremely secretive during most of its life or occurs in sparse populations even within its preferred habitats.

3. The climatic changes occurring in the last 10,000 years may have caused it to contract a former distribution extending from Baja California Sur to southern California.

For whatever reasons Anarbylus remains rare, potential problems exist which will effect management efforts involving this species and the desert areas it inhabits. There is danger that an intense interest in the collection, captive maintenance and sale of Anarbylus switaki exists and will be amplified in the future. Such pressures could result in a great deal of damage to rock habitats and associated biota in southern California's arid lands. The common collecting techniques of prying rock flakes and cap rocks and moving small to large boulders with iron bars and other tools is a practice which results in obliteration of desert varnish on granite exposures, increases erosion, exposes microhabitats critical to insects, arthropods and small vertebrates to drying and temperature extremes and visually disfigures an area of exceptional beauty

and recreational value. That such activities can destroy geological formations and biological habitats that take thousands of years to develop is well known.

An example of the possible effects was noted in the course of this study. Although I attempted to minimize impact on rock formations by employing pitfall and visual search techniques, others were less considerate at one of my study sites near Mountain Springs in San Diego County. Mountain Springs is an area which has been subjected to some collecting activity by professional and amateur reptile collectors for many years. However after a San Diego State University student removed an Anarbylus from one of my pitfall traps without my knowledge and allowed the collection site to become known to a small group of reptile enthusiasts, a noticeable increase in habitat destruction at Mountain Springs was evident. Flakes were shattered, rocks moved from earthen pedestals and undersurfaces of many boulders were left exposed. Although the persons responsible for this destruction are unknown to me, there is little doubt that such activity was related to search for Anarbylus, either for pets or for commercial sale. Based on my experience over a three-year period, it would be necessary to turn thousands of rocks for every Anarbylus collected. Thus the danger to the habitat is probably greater than to the lizard itself. However such consideration may be sufficient justification for full legal and regulatory protection for Anarbylus switaki throughout California. The granite hillsides with which Anarbylus is associated are natural wonders which impress all visitors who pass through the area. These same geological formations are the primary habitats for a variety of rock-dwelling lizards, some of which occur in the United States only in extreme southern California.

Following the discovery of Coleonyx reticulatus in western Texas in 1958, an intense interest developed among both amateur and commercial reptile collectors. C. reticulatus shares several characteristics with Anarbylus that

probably account for such interest.

1. An unusual lizard with a striking color pattern.

2. Relatively rare and restricted in distribution.

3. Delicate appearing animals easily maintained in confined cages or terreria.

In the course of duties as Curator of Reptiles at the San Diego Natural History Museum over a 5-year period, I met more than eight amateur herpetologists who, with no legitimate reason for possessing Coleonyx reticulatus, had collected and maintained the species despite the distance between Texas and California. The state of Texas has deemed such interest and collecting pressure justification for full protection of the species and requires specific permits even for scientific purposes. Similar protection for Anarbylus by the State of California and the federal agencies with jurisdiction over lands occupied by the taxon may be desirable and necessary to prevent habitat disruption and excessive collectiong pressure. Widespread interest is known to exist among commercial collectors and pet traders and consideration of management policies must precede further dissemination of information on this gecko.

Painted Gorge, one of the principal sites for Anarbylus is with a BLM managed area with a long history of use by the public for camping, hiking and rock hounding. In recent years such uses have been overshadowed by off-road vehicle enthusiasts who are drawn by the undulating badland hills with sparse vegetation, the complex network of sandy washes and close proximity to I-8 and municipal areas. Motorcycle and dune buggy activity is concentrated on low ridges and hills which have been totally denuded of vegetation and accompanying animal life. The ecologically sensitive species of Uma notata and Phrynosoma mccalli are known to occur in sandy washes and alluvial fans near this area and should be monitored closely for possible effects by ORV activity because their habitats are confined to those areas most attractive

for ORV use. Many slopes are too steep, broken by rock rubble and dissected by arroyos to allow vehicular activity, but impact of vehicular recreational activity on Anarbylus is possible.

Mining and gravel extraction in the Coyote Mountains/Painted Gorge area is minimal at present although several mines and rock debris piles are visible. Because Anarbylus and several other restricted species of lizards are so intimately associated with rock habitats, consideration should be given to possible effects on these biological resources of any future mining attempts. A significant gypsum mining site exists in the Fish Creek Mountains where Anarbylus is expected, but to date is unknown.

Of particular significance to the management of the eastern periphery of of the desert foothills area is the patchy nature of rock habitats. In contrast to areas further west, rock habitats in Painted Gorge are quite restricted in nature with mud and mudstone canyon walls, gravel canyon floors and sandy washes intimately interdigitated and much more extensive than other localities where Anarbylus was observed or is expected. As a result of the scarcity of rock exposures except on specific slopes, such exposures are critical to the continued survival of Anarbylus and other animals confined to or dependent on rock habitats. Therefore rock habitats in the Coyote Mountains and the similar Fish Creek Mountains warrant special consideration in management and land use decisions. The area illustrated in Figure 10 is the only extensive rock habitat in the Painted Gorge area and the only site within the Coyote Mountains where Anarbylus is known even though other areas were examined to an equal or greater extent.

On the basis of existing knowledge it is difficult to determine the exact ecological status of Anarbylus in southern California. However on the basis of the apparent scarcity of individuals and restricted distribution of

the species, Anarbylus must be considered an ecologically sensitive species warranting protection by state and federal agencies. In order to provide some control over the commercial sale of this species, a request for the prohibition of collection of the species in California except for scientific purposes is being prepared for the State of California. In addition, special consideration of potential human impact on the areas from which Anarbylus is presently known is warranted. Since the major sites from which the gecko is known are of major scenic and recreational value and under the jurisdiction of the Bureau of Land Management and Anza-Borrego Desert State Park, a cooperative protection, research and/or management plan might be desirable.

ACKNOWLEDGMENTS

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LIST OF FIGURES

Figure 1. An adult female with a regenerated tail of Anarbylus switaki from the vicinity of the North Fork of Pinto Canyon, ≈ 500 m, Imperial County, California. Snout-vent length 83mm.

Figure 2. A juvenile of Anarbylus switaki with a tail regenerated from the caudal constriction from 1 km NW of the junction of Pinto Canyon and Davies Valley near the international boundary between Mexico and California, Imperial County, California. Snout-vent length 53mm.

Figure 3. An adult male of Anarbylus switaki from Painted Gorge, Coyote Mountains, Imperial County, California. Snout-vent length 68mm.

Figure 4. Distribution of Anarbylus switaki in San Diego and Imperial Counties, California. Each locality is indicated with an "X". The extent of desert foothill association (from Klauber, 1931) is delimited in solid lines.

Figure 5. Hypothesized relationships of Anarbylus switaki in relation to other eublepharine geckos of North America (after Kluge, 1975).

Figure 6. Granodioritic boulder piles in the eastern escarpment of the Jacumba Mountains near Smugglers Cave, ≈ 1100 m, western Imperial County, California. Anarbylus switaki is expected to range into this area of extreme scenic beauty.

Figure 7. The desert foothill slopes on the eastern face of the Jacumba Mountains between Davies Valley and Smugglers Cave in Imperial County, California.

Figure 8. Rock habitats and associated vegetation in the Pinto Canyon area of Imperial County, California.

Figure 9. The stippled area delimits those areas of the desert foothill association where Anarbylus switaki is most likely to occur (see Figure 4).

Figure 10. Rock habitats in interior of Painted Gorge where Anarbylus switaki is known. View is toward Plaster City and Painted Gorge ORV area, both of which are hidden by ridges in photograph.

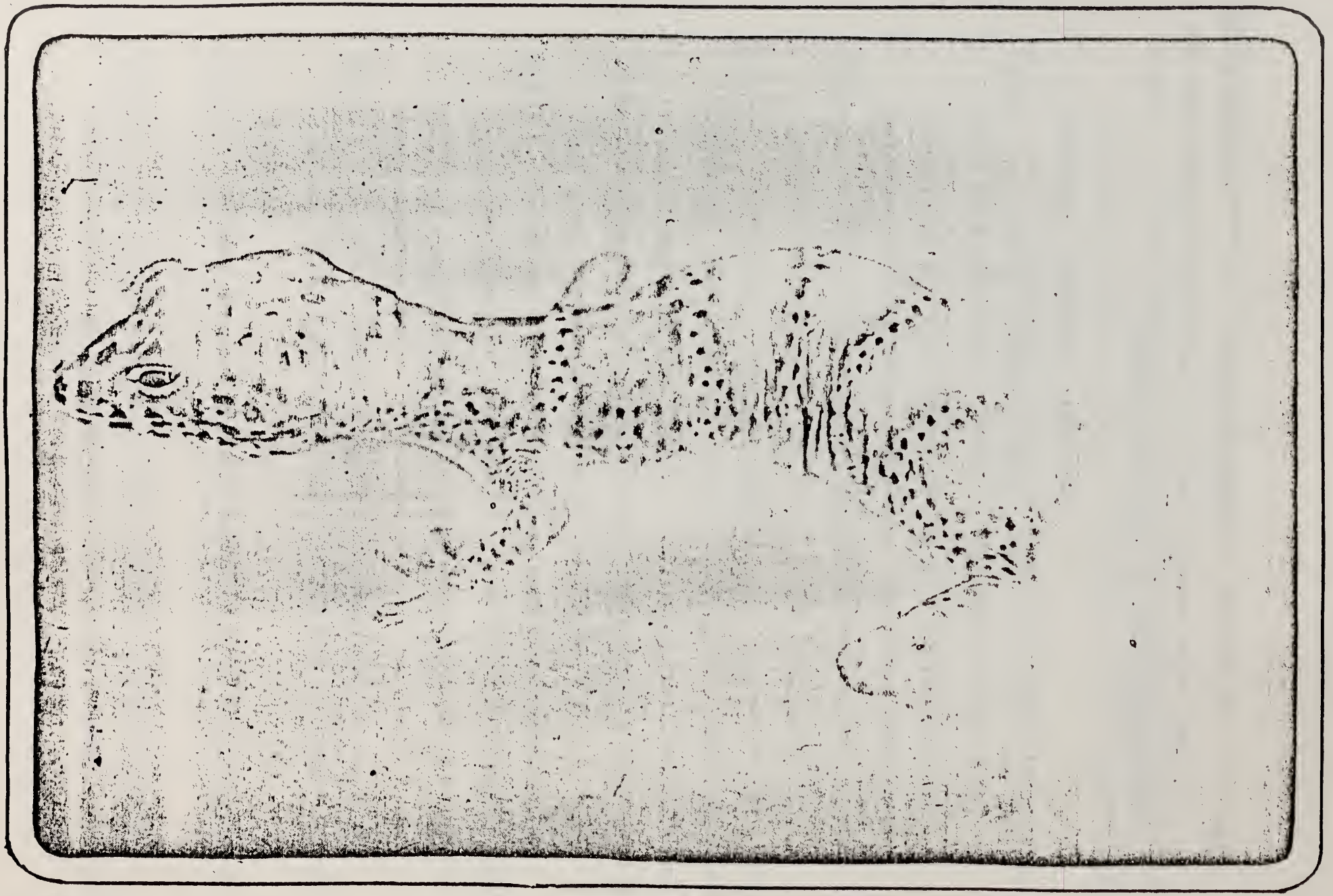


Figure 1.

Figure 2.

Figure 3.

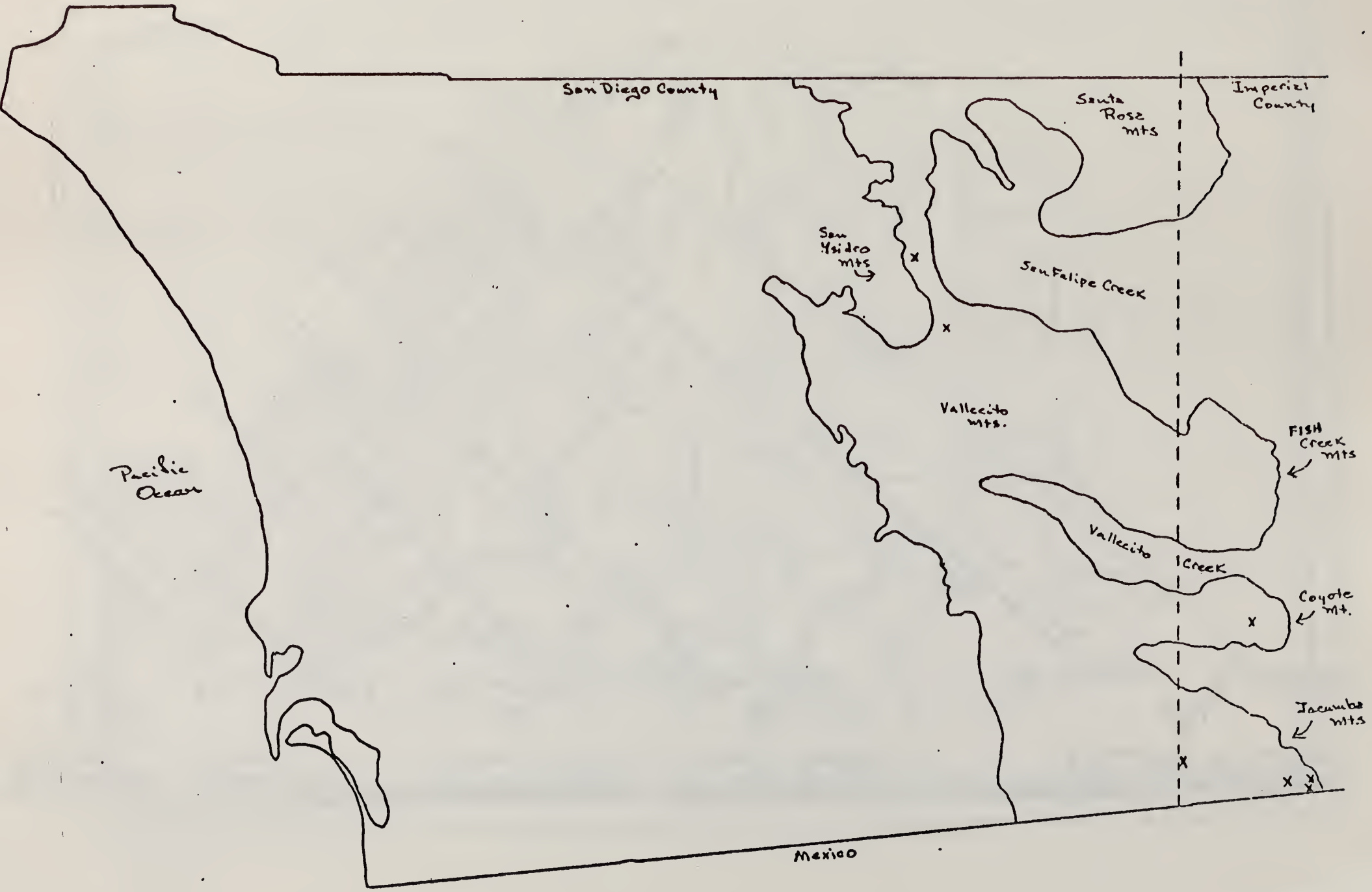

San Diego County
Imperial County
Santa Rosa mts
San Ysidro mts
San Felipe Creek
Vallecito mts.
FISH Creek mts
Pacific Ocean
Vallecito Creek
Coyote Mt.
Jacumba mts
Mexico

Figure 4.

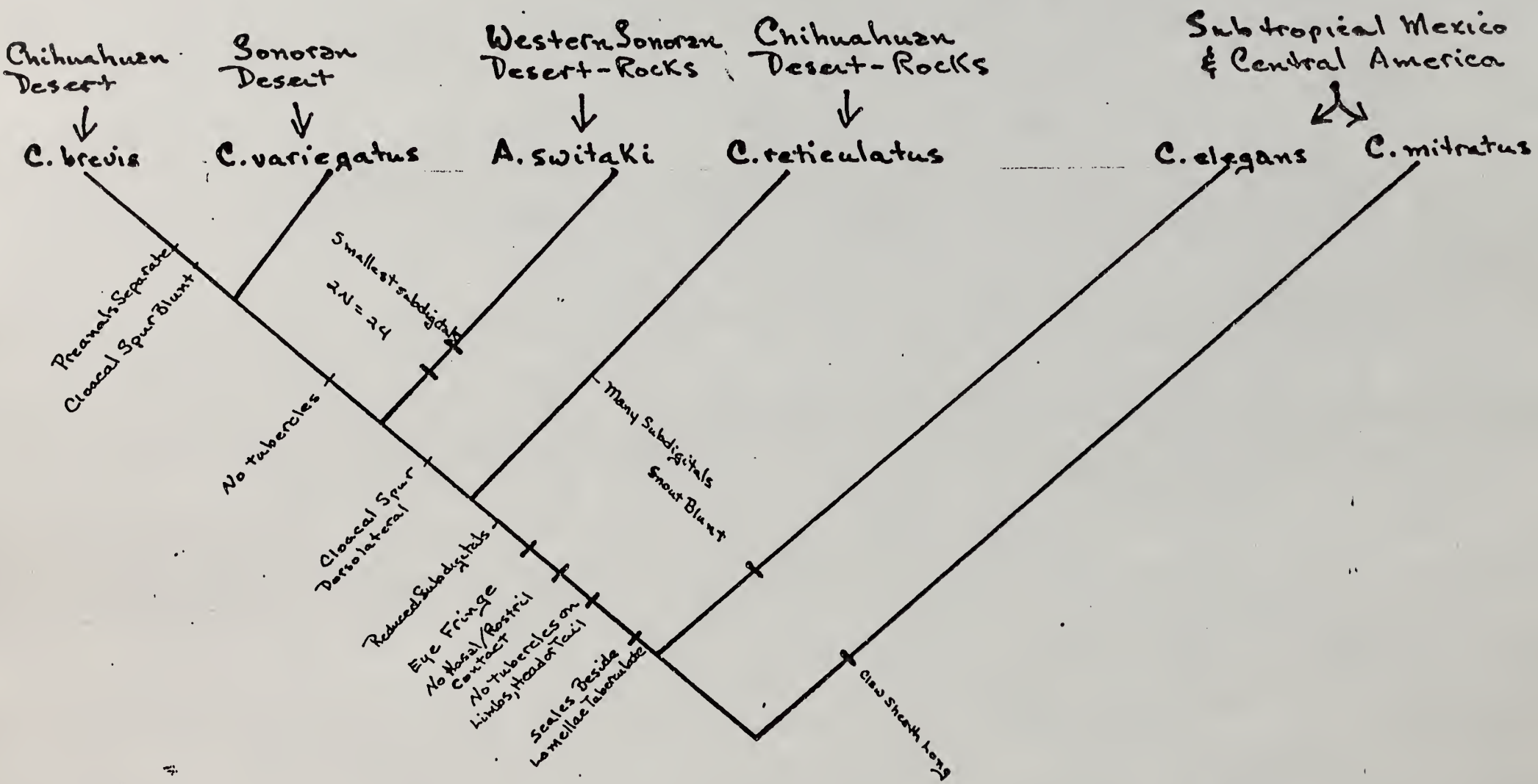
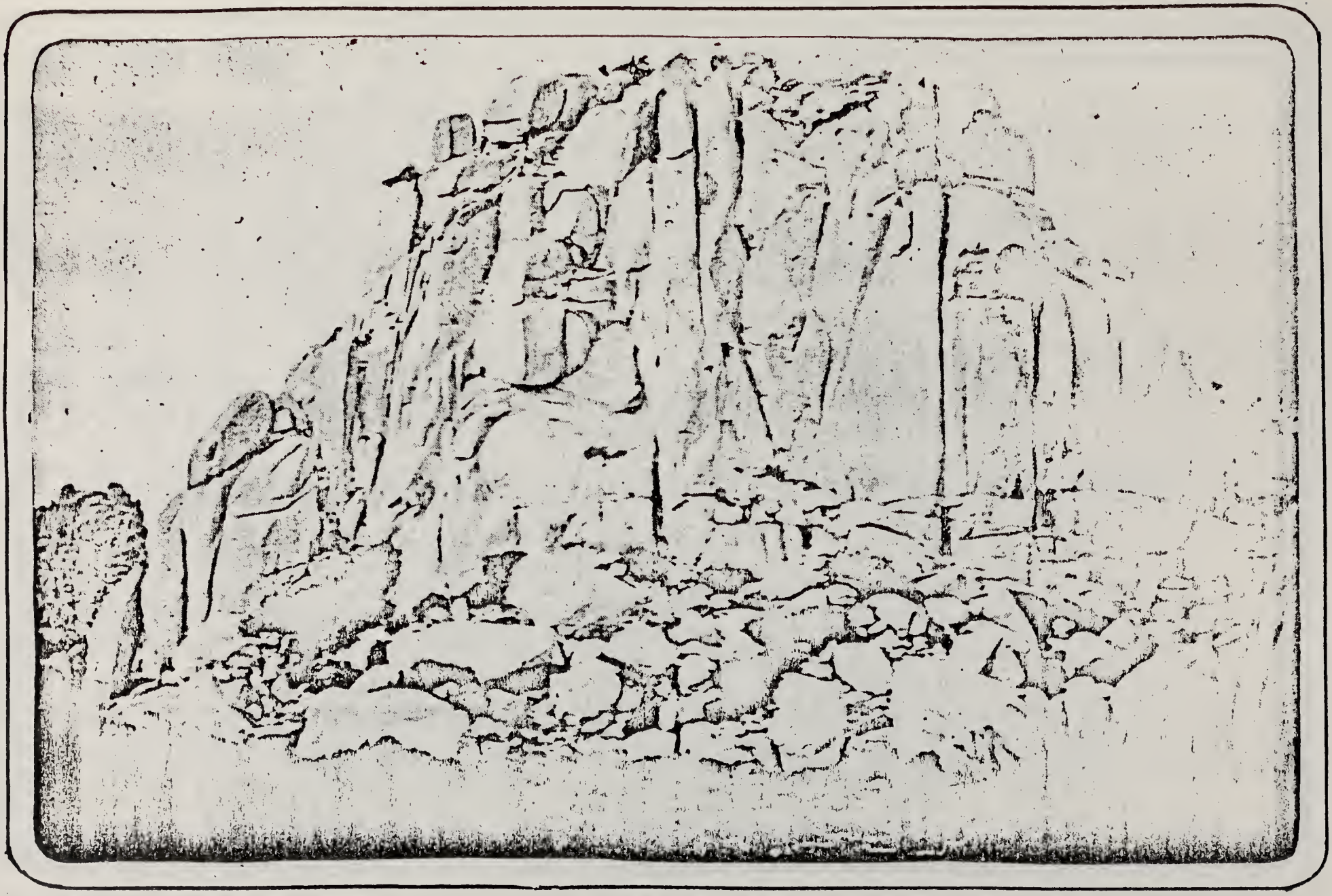

Chihuahuan Desert
Sonoran Desert
Western Sonoran Desert-Rocks
Chihuahuan Desert-Rocks
Subtropical Mexico & Central America
C. brevis
C. variegatus
A. switaki
C. reticulatus
C. elegans
C. mitratus
Preanals Separated
Cloacal Spur Blunt
Smallest subdigitals
2N = 24
No tubercles
Cloacal Spur Dorsolateral
Many Subdigitals
Snout Blunt
Reduced Subdigitals
Eye Fringe
No Nasal/Rostril Contact
No tubercles on Limbs, Head or Tail
Scales Beside Lamellae Tuberculate
Claw Sheath long

Figure 5.



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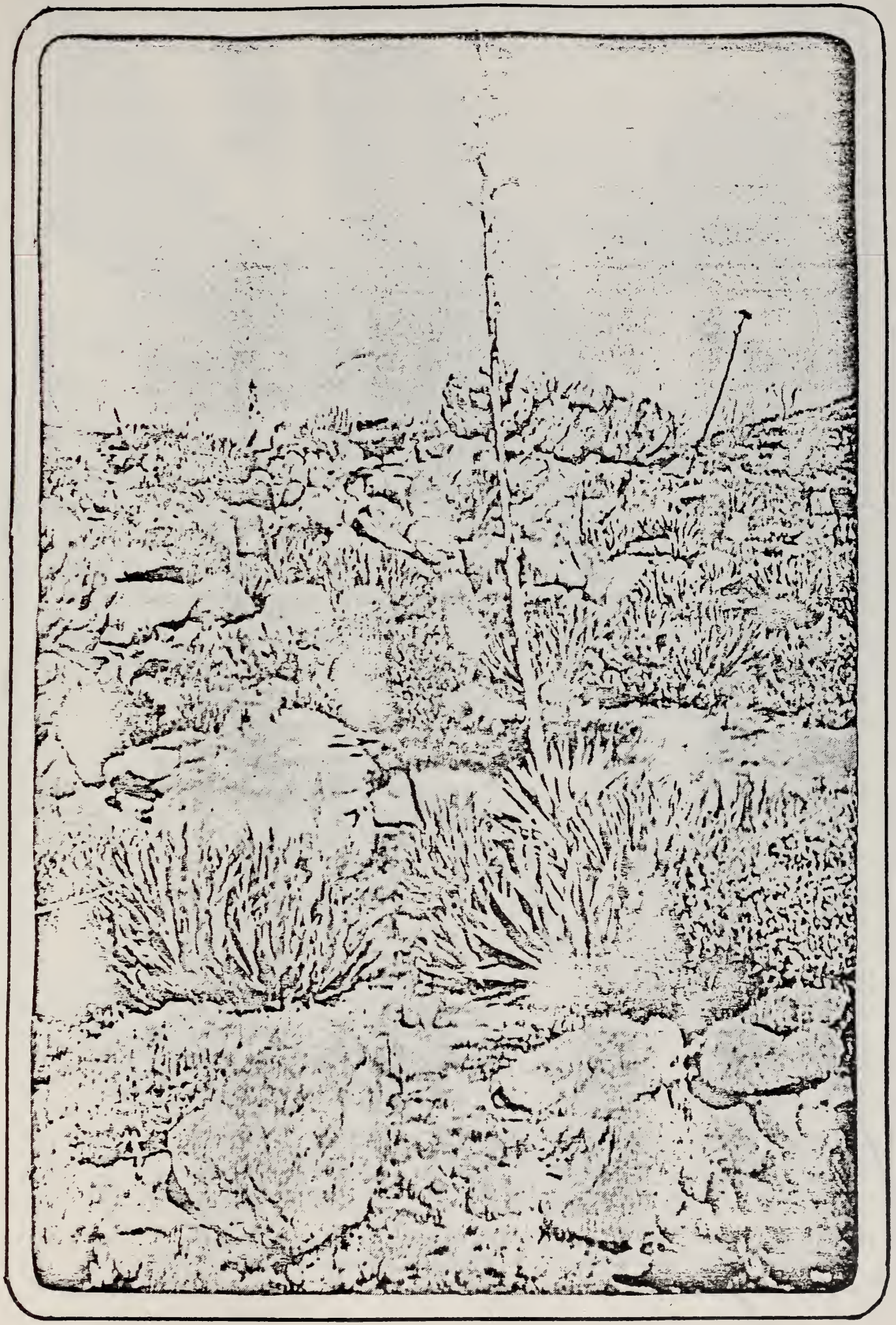

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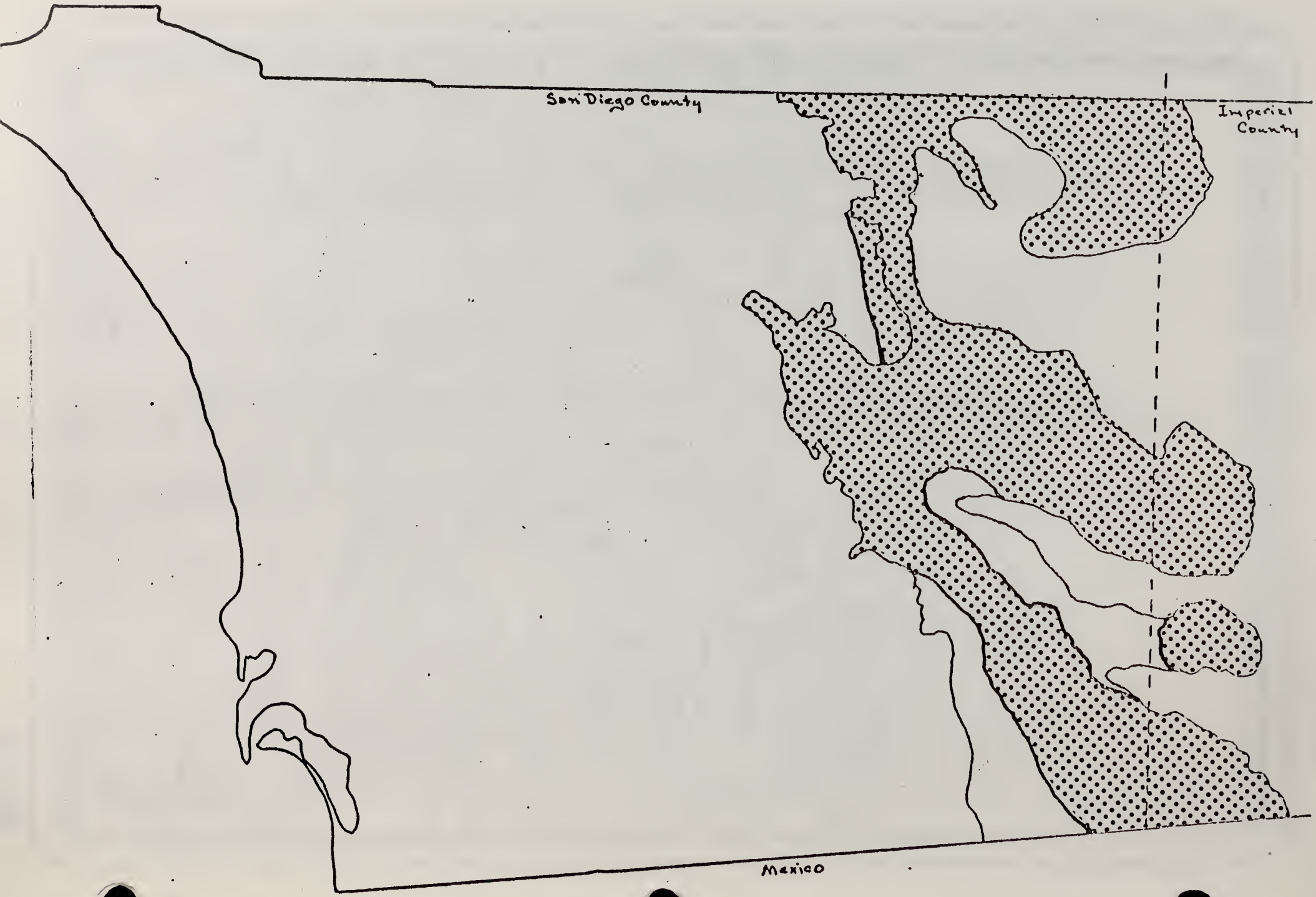

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Figure 10.

Table 1.-- Summary of Morphological Comparisons of Samples of Anarbylus switaki.

Characteristic	Holotype San Ignacio	Sta. Rosalia	Bahia Los Angeles	Southern California*
Subdigital lamellae of 4th toe	18	17-19	17	17-18
Subdigital lamellae of 4th finger	14	12-16	13	14-15
Supralabials	9	11-13	10-11	9-11
Infralabials	10	13-14	12	11-12
Scales of eye fringe	36-37	41-45	33-34	30-35
Bands between limbs	9	9-9½	8½	5-7
Bands from forelimbs to caudal constriction	12	12	10	7-9
Postnasals	1	2	1	1-2
Preanal pores		6-8	4	2-6?
Dorsal pattern	Spots	Spots	Spots & Bands	Bands
N	1	3	1	5

*Two living specimens are excluded from southern California sample but fall within the ranges presented in all attributes examined.

Table 2.--Lizards Recorded in Sympatry with Anarbylus switaki in southern California.

	Primarily Rock	Absolute Sympatry	Primarily Peninsular
Gekkonidae			
1. Coleonyx variegatus		X	
2. Phyllodactylus xanti	X	X	X
Iguanidae			
3. Dipsosaurus dorsalis		X	
4. Sauromalus obesus	X	X	
5. Callisaurus draconoides		X	
6. Uma notata*			
7. Crotaphytus insularis	X	X	
8. Gambelia wislizeni		X	
9. Sceloporus magister		X	
10. Sceloporus orcutti	X	X	X
11. Uta stansburiana		X	
12. Urosaurus microscutatus	X		X
13. Urosaurus graciosus		X	
14. Phrynosoma platyrhinos		X	
15. Phrynosoma mccalli*			
16. Petrosaurus mearnsi	X	X	X
Xantusidae			
17. Xantusia henshawi	X	X	X
18. Xantusia vigilis		X	
Scincidae			
19. Eumeces gilberti		X	
Teiidae			
20. Cnemidophorus tigris		X	
TOTAL 20	7	17	5

*Known from same localities as Anarbylus but in sand habitats.

APPENDIX I

LOCALITIES SAMPLED WITH PITFALLS DURING 1978

Fish Creek Mountains

Two sites were sampled near the northeast quarter of the Fish Creek Mountains. These sites were selected because they represented the least barren slopes of this range and provided access from the road paralleling the railroad serving the gypsum mine and Plaster City gypsum plant. The sites are noted as North and East sites to distinguish them, but the names merely refer to their relative position to one another.

North Fish Creek Mountain Site.--T13S,R9E,Sec21NE¼; approximately 4 km E Split Mountain, elevation 61 m. This site consisted of 10 pitfalls spaced at 10 m intervals and installed adjacent to a rocky northeasterly facing slope. Most traps were installed in sand or cobble substrates adjacent to a small arroyo following the contours of the slope.

East Fish Creek Mountain Site.--T13S,R9E,Sec22NW¼; approximately 5.5 km E Split Mountain, elevation 15 m. This site is in an adjacent cove to the east and south of the north Fish Creek site. Although it is also close to a rocky slope, the 10 pitfalls were placed in an alluvial slope composed of fine sand and silt and in a line perpendicular to the edge of the rocky area. The differences in proximity to rocky habitats and differences in soil composition between north and east Fish Creek sites is reflected in the presence of Amnospermophilus leucurus and Spermophilus tereticaudus respectively at the individual sites.

Coyote Mountains

Two sites were studied on BLM lands on opposite sides of the Coyote Mountains near the village of Ocotillo. Although extensive rock exposure is

minimal throughout most of this mountain range, an attempt was made to locate a series of 10 pitfalls as high on the alluvial slopes of the western Coyote Mountains as possible. Such a locality would differ most from the relatively well-known areas near the S-2 Highway. Another series was placed in the most densely vegetated area of the badlands near Painted Gorge for similar reasons.

West Coyote Mountain Site.--T16S,R9E,Sec6,NW¼; approximately 11 km NW Ocotillo, elevation 270 m. This site is located approximately 200 m from the San Diego/Imperial County line which coincides with the boundary of the Anza-Borrego Desert State Park. The 10 pitfalls transect a low ridge near the steep ridge of the main mountain mass. They are in gravel, sand and small cobble substrates.

Painted Gorge Site.--T16S,R9E,Sec2,NW¼; 9 km NNE Ocotillo, elevation 366 m. This site is well within the Painted Gorge area on the southeast side of Coyote Peak. The majority of the surrounding mudhills are sparsely vegetated badlands. The east facing slopes sampled are near a prominent igneous rock outcrop and are in close proximity to abundant rock litter.

North Davies Valley

This locality is at the junction of the lower edge of large intrusive volcanic formations that form the Jacumba Mountains and the lower basaltic ridges which extend into the Colorado Desert Basin. It lies to the north of Davies Valley and is separated from the main valley by a low ridge of boulders. An attempt was made to sample two habitats, the granitic boulder slopes and the slightly lower gravel fans that are derived from them.

North Davies Valley Rock Site.--T16S,R9E,Sec11,SW¼; approximately 5.5 km SW Ocotillo, elevation 375 m. A series of 10 pitfalls was installed in decomposed bedrock between granitic boulders.

North Davies Valley Sand Site.--T16S,R9E,Sec11,SW¼; approximately 5.5 km SW Ocotillo, elevation 366 m. Ten pitfalls extend perpendicular to the rocky valley wall across an alluvial fan of decomposed parent rock.

Mountain Springs

T16S,R9E,Sec21,NW¼; 3 km E Mountain Springs on old Highway 80, elevation 586 m. This site has been monitored continuously for over one year. It resembles the North Davies Valley rock site except for the presence of various plant species occurring only at higher elevations.

In-Ko-Pah

T17S,R9E,Sec31,SW¼; 1.5 km SE In-Ko-Pah County Park near the San Diego/ Imperial County line, elevation 958 m. A series of 10 pitfalls extend up a northeasterly facing rocky hillside.

North Fork of Pinto Wash

Twenty pitfall traps have been monitored in an area of extensive granitic boulder formations. Because of the remote location of this site, the area is visited at irregular intervals dictated by daytime temperatures and availability of field time.

In summary a total of 100 pitfalls were used to monitor vertebrate distributions in a variety of microhabitats ranging from 15 m to 968 m.

APPENDIX II

KEY TO SPECIES OF EUBLEPHARINE GECKOS OF NORTH AMERICA

1A Cloacal tubercle (spur) originating ventral to middle of insertion of thigh, short, blunt in males and females. Sheath of scales surrounding base of claw moderately large, covering all but distal tip of claw.

_____ 2

1B Cloacal tubercle (spur) originating dorsal to middle of thigh insertion, elongate and spinose in males; sheath of scales surrounding base of claw moderate to reduced covering only base of claw.

_____ 4

2A Enlarged tubercles on the head, limbs and proximal tail; body tubercles large and closely positioned; nasal in contact with rostril, no contact between large prenasal and first supralabial; scales adjacent to central row of subdigital lamellae of toes imbricate, not granular or tuberculate. Preanal pores in angular series, not extending onto ventral surface of thighs.

_____ 3

2B No enlarged tubercles on head, limbs or tail posterior to caudal constriction; nasal separated from rostril by large prenasal which contacts first supralabial; scales adjacent to central row of subdigital lamellae small, tuberculate or subimbricate; preanal pore series only slightly angular, extending onto ventral surface of thighs.

Coleonyx reticulatus

3A Claw sheath large, claw hidden by sheath or only tip of claw extending beyond sheath; snout long, relatively pointed; tympanum moderate in size.

Coleonyx elegans

3B Claw sheath shorter, allowing curvature of claw to protrude; snout short, blunt; tympanum small in size.

Coleonyx mitratus

4A Dorsum with enlarged tubercles among smaller granules; subdigital lamellae similar to adjacent scales, nonimbricate, small, not wider than long except near distal tip of digit.

_____5

4B Dorsal scutellation composed of uniform granules; subdigital lamellae somewhat wider than long, distinguishable from adjacent scales which are granular.

_____6

5A Dorsal body marked with transverse rows of white spots, 3 or more complete transverse rows between girdles.

Anarbylus switaki (Mexico)

5B Dorsal body marked with transverse bands of white or yellow white pigment, 5-7 complete bands between girdles.

Anarbylus switaki (S. Calif.)

6A Preanal pores of males separated medially by one or more small scales; snout blunt; distal end of cloacal spur flat, broad.

6B Preanal pores of males not separated medially; snout pointed; distal end of cloacal spur pointed.

Coleonyx variegatus

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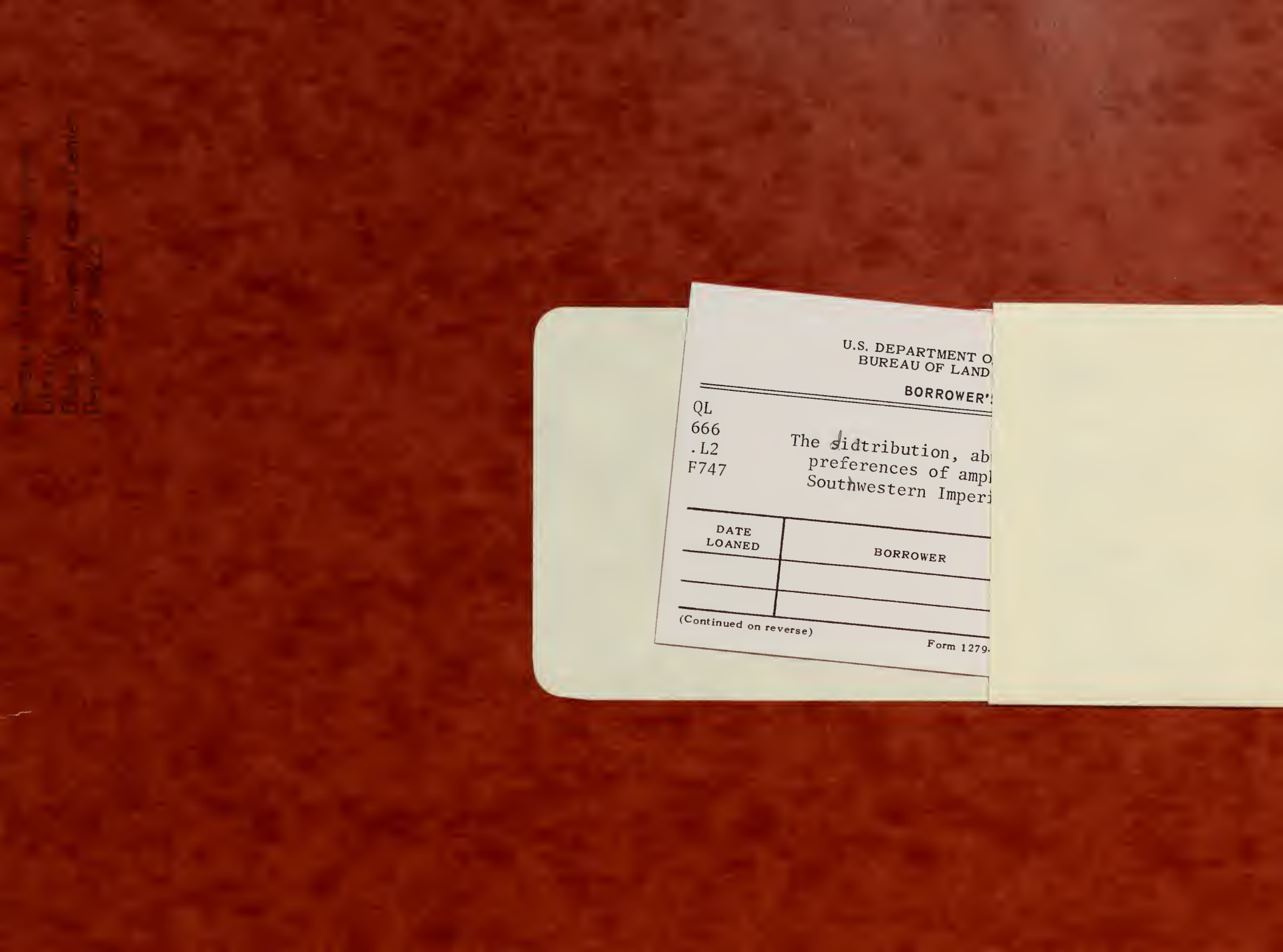
Bldg. 50, Denver Federal Center
Denver, CO 80225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